Sharp emission from InAsP/InP quantum dots

F. E. Faradjev, E.A. Hakobyan

The Svedberg Laboratory, Uppsala University, Box 533, S-751 21, Sweden

PACs No: 78.66.Fd; 73.20.Dx; 85.30.Vw; 81.15.Gh; 68.35.Bs; 78.55. -m; 61.16.Ch

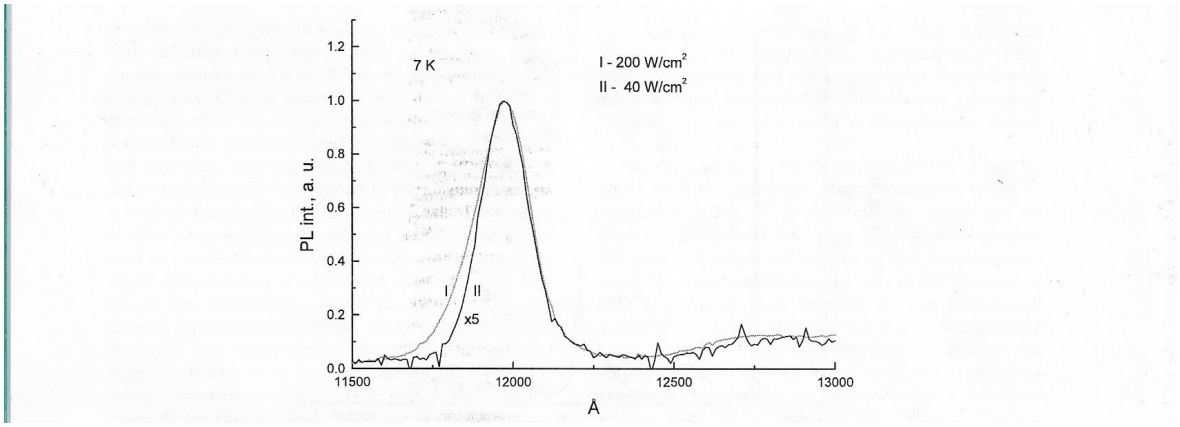
The vitality of research of semiconductor quantum-dimensional structures is explained by their potential for creating a new generation of optoelectronic devices as well as for use in biophotonics.
Emission at 1200 nm is using in advanced imaging and medical applications because it penetrates tissue more deeply than visible or first near-infrared light.

We report on optical studies of self-assembled InAsP quantum dots (QDs) formed on InP. These dots show sharp and bright photoluminescence at 1200 nm.

The photoluminescence (PL) in self-assembled InAsP quantum dots (QDs) formed on InP by As/P exchange reaction has been measured in the temperature range 3.8-300 K and excitation power range 0.1-200 W/cm2. Samples were prepared in a low-pressure (76 Torr) metalorganic chemical vapor deposition (MOCVD) reactor. QDs were formed at 650° C for 10 min in PH3/AsH3 (105/5) flux on the InP buffer layer after it was exposed to the air and then wet etched to some depth. Size distribution of QDs was evaluated by atomic force microscopy (AFM). AFM demonstrates only the large QDs with the height about 40 nm. Both AFM and PL measurements were performed on the same uncapped samples in order to prevent the effect of capping layer on the QDs geometrical parameters and to avoid the consequent lack of correlation between AFM and PL results.

The PL spectrum of samples exhibits clearly seen double-peak feature, and also extremely sharp for an ensemble of quantum dots peak centred at 1197 ,5 nm. Some small shift of the line (within 10 nm) probably due to the deviation in size distribution of excited dots was observed when changing the position of the laser beam. The value of FWHM of this peak was only about 14 meV at the excitation power density 50 W/cm2

and decreased with decreasing excitation intensity. The observed value of FWHM indicates good uniformity of dots and is the lowest value obtained up to now for an array of 111-Y QDs grown by different methods, where the typical F\VHM of PL spectra is 22-150 meV, with the lowest value of 21 meV obtained for srained reduced InAs QDs covered by InGaAs and grown on GaAs by GSMBE [1]. We have measured PL spectra at different excitation power level and found originating from the state filling of the QD ground state relative increase of the higher energy side of the dominant peak with increasing excitation (Fig. 1). The amplitude of both peaks in the spectrum appeared to increase linearly with the excitation with approximately the same rate. It is consistent with our results obtained earlier [2] and indicates that these two peaks originate from dots of different size or composition branches. The linear dependence of PL intensity on the excitation also indicates the low density of stress related defects in the QDs. We measured also the temperature dependence of PL intensity for all samples and found that the emission was within 30% stable up to room temperature.



References:

[1] K. Nishi, H. Saito, S. Sugou, and J. -S. Lee, Appl. Phys. Lett. 74, 1111 (1999).
[2] F. E. Faradjev, Material Science and Engineering, B94, 243 (2002).